## A utility-based, multi-sector framework for local scale land-use modeling

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# A utility-based, multi-sector framework for local scale land-use modelling

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Local land-use changes are driven by a wide range of social, economic and biophysical forces. These forces have a different impact on the various societal sectors that influence the land-use system. Urbanisation is typically driven by factors such as economic development, accessibility and spatial planning, agriculture is strongly influenced by general agro-economic and local biophysical conditions, while changes in natural areas generally result from (the presence or lack of) agricultural perspective and policy interventions. Obviously the strength of these forces varies across time and space. Land-use models that simulate spatial developments can apply a wide range of theories and methods to explain the magnitude and location of change (see, for example, Koomen and Stillwell, 2007). A crucial component in most land-use models is the definition of local suitability of land for various types of use that is normally done by statistical analysis or expert judgement (Lesschen et al., 2005; Verburg et al., 2004). The causal relations that link the underlying decision making processes to the observed changes in land use are generally poorly represented in these approaches (Munroe and Muller, 2007). Yet, data-driven inductive approaches are popular because they tend to perform better in reproducing existing spatial patterns (Overmars et al., 2007b). Overmars et al. argue, however, that a deductive theory-induced approach should be better equipped to understand causal relations and ongoing processes. Attempts to introduce a deductive approach to land-use modelling are relatively scarce and tend to focus on land-use changes that relate to single-sector processes such as agricultural practices (Overmars et al., 2007a) and residential development (Ettema et al., 2007). This is due to the fact that reproducing observed land-use patterns (the typical procedure in validating model outcomes) following a deductive approach is much harder in models that simulate multiple land-use change processes than models that simulate single land-use change processes (van Schrojenstein Lantman et al., 2011).

We propose an integrated approach that can be used to simulate local land-use changes for multiple societal sectors simultaneously. In fact, we will follow the invitation of (Overmars et al., 2007a) to seek the interaction between inductive and deductive work. The framework aims to combine the strengths of the available concepts, approaches and techniques of different disciplines (as advocated by Verburg et al., 2004) instead of elaborating on approaches belonging to a specific discipline. A crucial issue here is to come to a unified assessment framework for land suitability that incorporates the local potential for different types of use (urban, agricultural and natural) based on, for example, market preferences, land-use related adaptation measures and biophysical conditions that change over time.

The proposed suitability framework defines local land suitability following a monetary (utility based) framework following the rationale of many existing land-use models. Suitability for a particular type of land use is calculated as the net benefits for that use, in line with bid-rent theory and the host of literature on land markets and land evaluation. This utility-based approach has the advantage that it allows for a unified assessment of land suitability that can be directly linked to human behaviour and can, potentially, be defined in a relatively objective way. It provides a common reference scale for the definition of suitability that allows for straightforward interpretation, direct comparison between different types of land use and regions, and a framework for the inclusion of future changes in location characteristics. It thus offers the possibility to insert discontinuities, policy alternatives or anticipated scenario-based changes, that are particularly relevant in the context of, for example, climate change. These advantages are lacking in alternative approaches such as pure statistical techniques, multi-criteria analysis or the analytical hierarchy process.

The suitability framework is implemented in the widely applied Land Use Scanner model (Hoymann, 2010; Koomen and Borsboom-van Beurden, 2011; Te Linde et al., 2011) and applied to a case study area where economic and biophysical processes interact and that is characterised by considerable dynamics in multiple sectors. The Netherlands fulfil these criteria and have the additional advantage that the necessary large amounts of spatial data are available.

## *References*

Ettema, D., de Jong, K., Timmermans, H. and Bakema, A. (2007) PUMA: multi-agent modelling of urban systems. Chapter 14. In: Koomen, E., Stillwell, J., Bakema, A. and Scholten, H.J. (eds.), Modelling land-use change; progress and applications. Springer, Dordrecht, pp. 237-258.

Hoymann, J. (2010) Spatial allocation of future residential land use in the Elbe River Basin. Environment and Planning B: Planning and Design 37(5): 911-928.

Koomen, E. and Borsboom-van Beurden, J. (2011) Land-use modeling in planning practice. Geojournal library, volume 101. Springer, Heidelberg.

Koomen, E. and Stillwell, J. (2007) Modelling land-use change; Theories and methods. Chapter 1. In: Koomen, E., Stillwell, J., Bakema, A. and Scholten, H.J. (eds.), Modelling land-use change; progress and applications. Springer, Dordrecht, pp. 1-21.

Lesschen, J.P., Verburg, P.H. and Staal, S.J. (2005) Statistical methods for analysing the spatial dimension of changes in land use and farming systems. LUCC report series No. 7. International Livestock Research Institute/LUCC Focus 3 Office, Nairobi/Wageningen.

Munroe, D.K. and Muller, D. (2007) Issues in spatially explicit statistical land-use/cover change (LUCC) models: Examples from western Honduras and the Central Highlands of Vietnam. Land Use Policy 24(3): 521-530.

Overmars, K.P., De Groot, W.T. and Huigen, M.G.A. (2007a) Comparing inductive and deductive modelling of land use decisions: principles, a model and an illustration from the Philipines. Human Ecology 35(4): 439-452.

Overmars, K.P., Verburg, P.H. and Veldkamp, T. (2007b) Comparison of a deductive and an inductive approach to specify land suitability in a spatially explicit land use model. Land Use Policy 24(3): 584-599.

Te Linde, A.H., Bubeck, P., Dekkers, J.E.C., De Moel, H. and Aerts, J.C.J.H. (2011) Future flood risk estimates along the river Rhine. Natural Hazards and Earth System Sciences 11(2): 459-473.

van Schrojenstein Lantman, J., Verburg, P.H., Bregt, A.K. and Geertman, S. (2011) Core principles and concepts in land-use modelling: a literature review. Chapter 3. In: Koomen, E. and Borsboom-van Beurden, J. (eds.), Land-use modeling in planning practice. Springer, Dordrecht, pp. 35-57.

Verburg, P.H., Schot, P.P., Dijst, M.J. and Veldkamp, A. (2004) Land use change modelling: current practice and research priorities. Geojournal 61: 309-324.